# Charged particle multiplicities in pp interactions at $\sqrt{s}$ = 0.9 , 2.36 and 7 TeV

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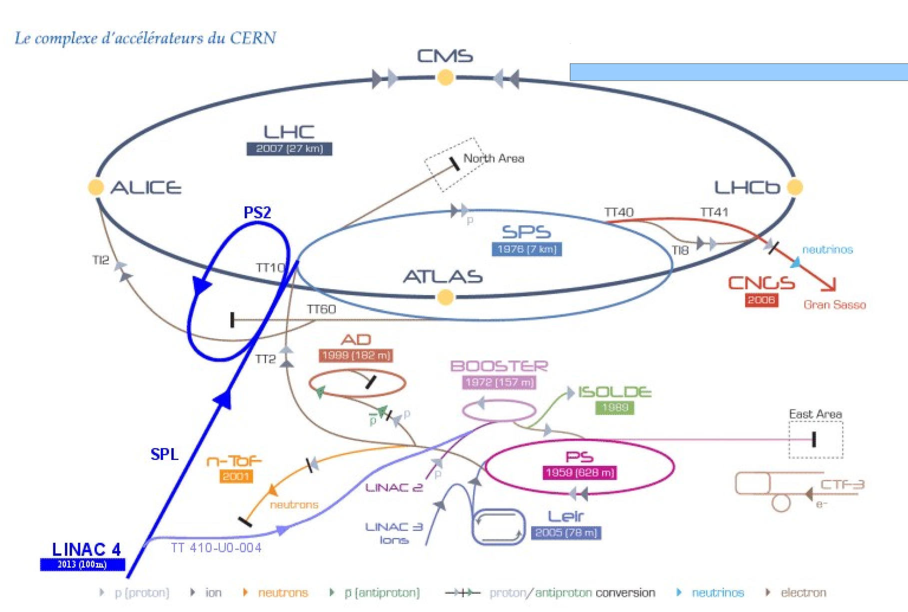
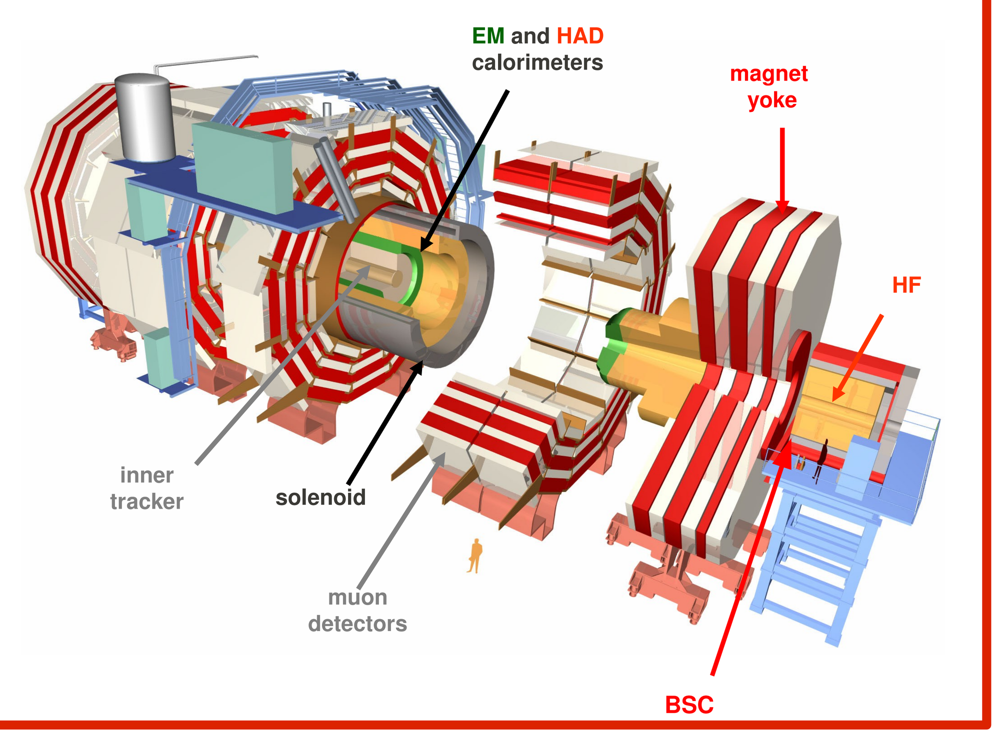
## The CMS experiment at LHC




## Triggering, event selection and data collected

**TRIGGER**
*To select collisions*

*Any hit in the beam scintillator counters (BSC)*
*AND*
*A filled bunch passing the beam pickups (BPTX)*

**+**

**OFFLINE EVENT SELECTION**
*To select good events*

*At least 3 GeV in both sides of the HF*
*+*
*Rejection of the beam halo using the BSC*
*+*
*Dedicated beam background rejection*
*+*
*At least one reconstructed vertex near the IP*

**=**

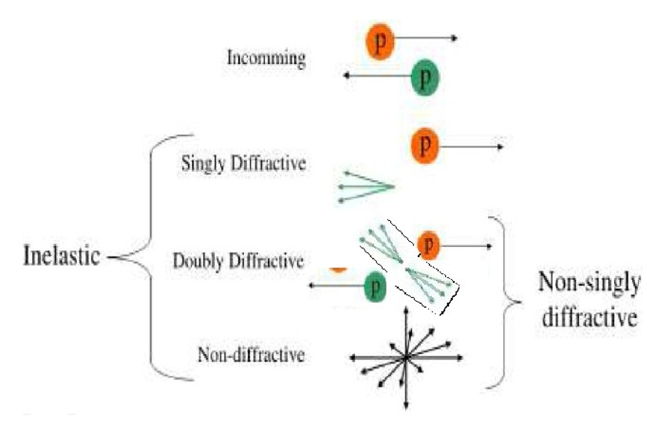
**Data Selected**

*At 900 GeV : ~ 130K events*
*At 2.36 TeV : ~ 12K events*
*At 7.0 TeV : ~ 440K events*

## Corrections : from tracks to charged hadrons

### SD Subtraction

*CMS measures essentially non-single-diffractive (NSD) events. Need to substract the SD events remaining after evt. selection*




### Unfolding

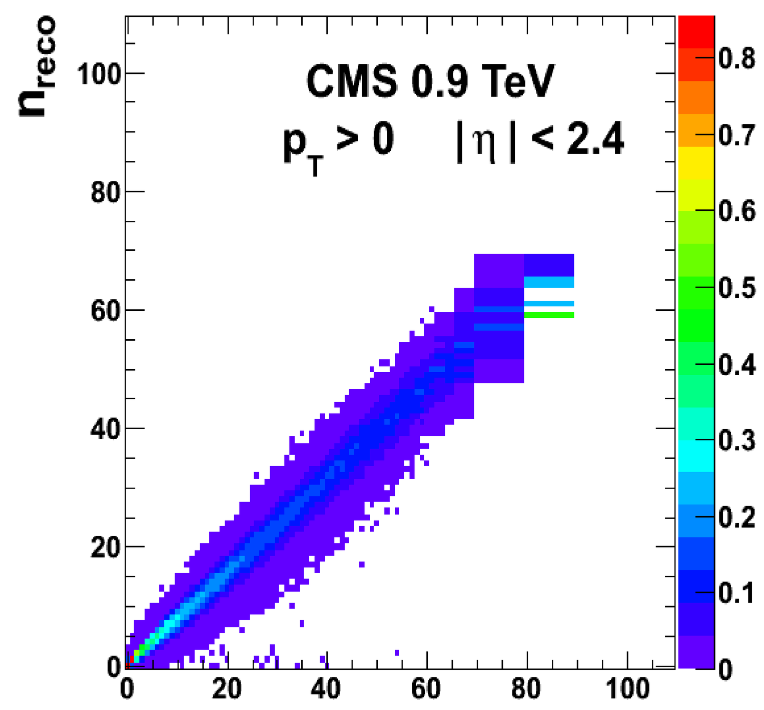
*Bayesian method by D'Agostini [1]. Corrects for detector features ( lost tracks , fake tracks ) , using a response matrix taken from simulation of the detector*

### Event Selection Correction

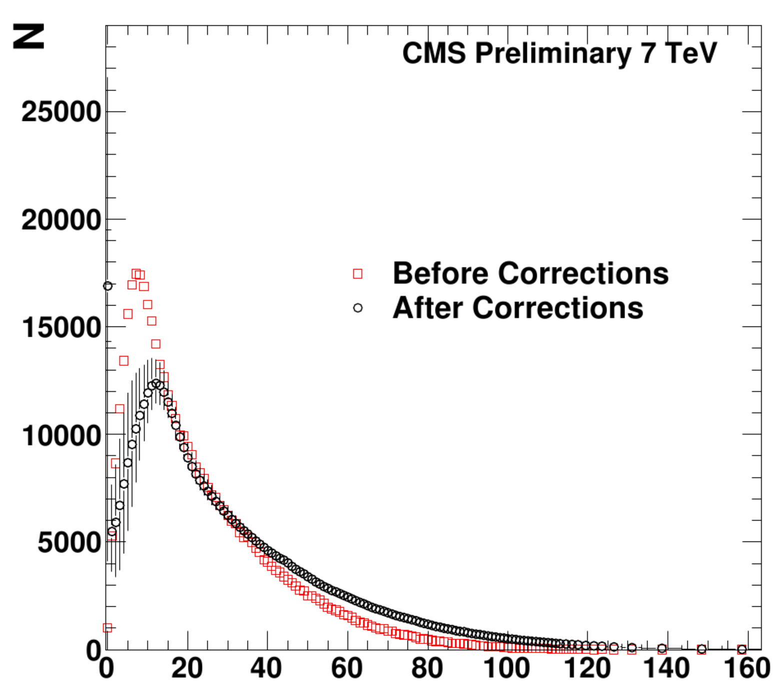
*Efficiency takes into account the multiplicity dependence of our event selection*

### <pt> Extrapolation Correction

*Monte-Carlo simulation underestimates the number of hadrons under 100 MeV ( lowest pt we can reach in the tracker ). The number of tracks/event has thus to be increased to fully correct.*




Response Matrix

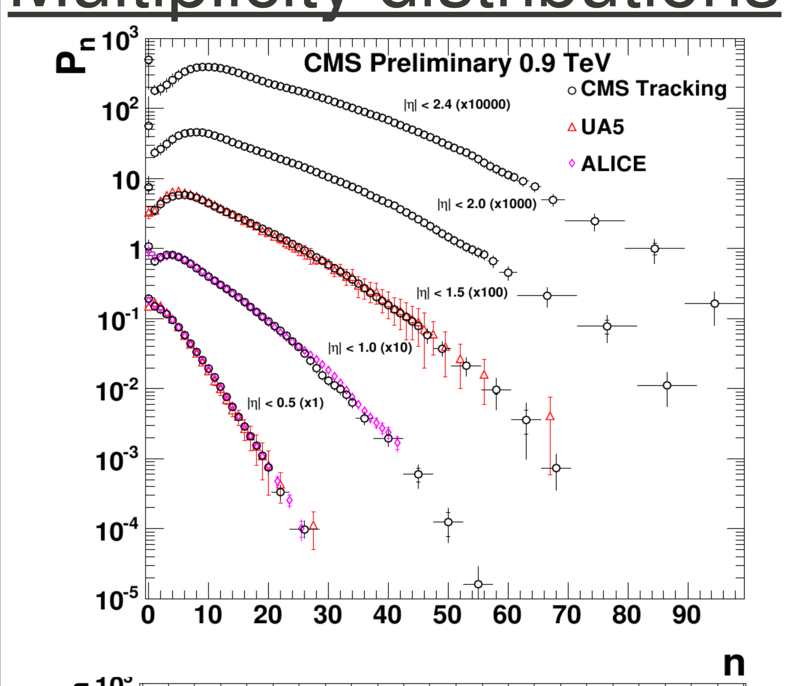


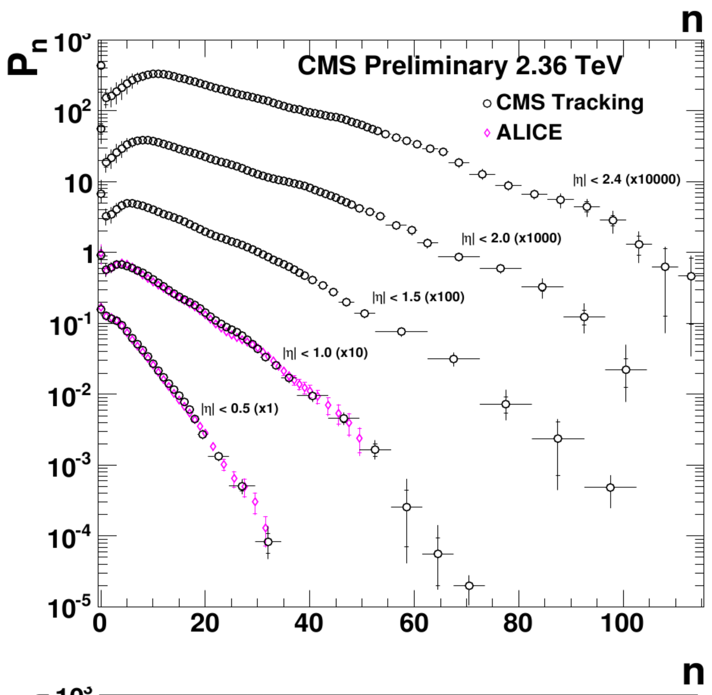

Effect of Corrections

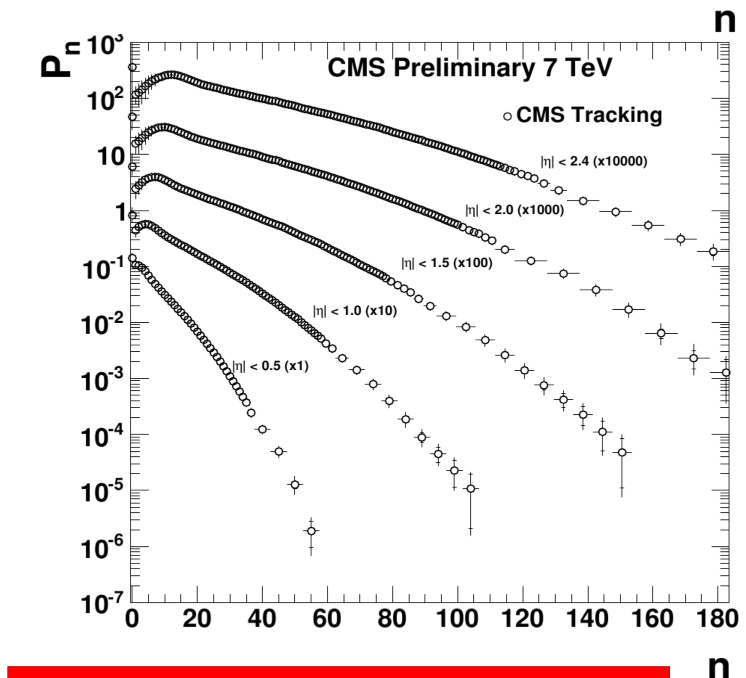
*Needed to see behaviour at new energy*

*Needed to tune MC simulations*

## Multiplicity distributions

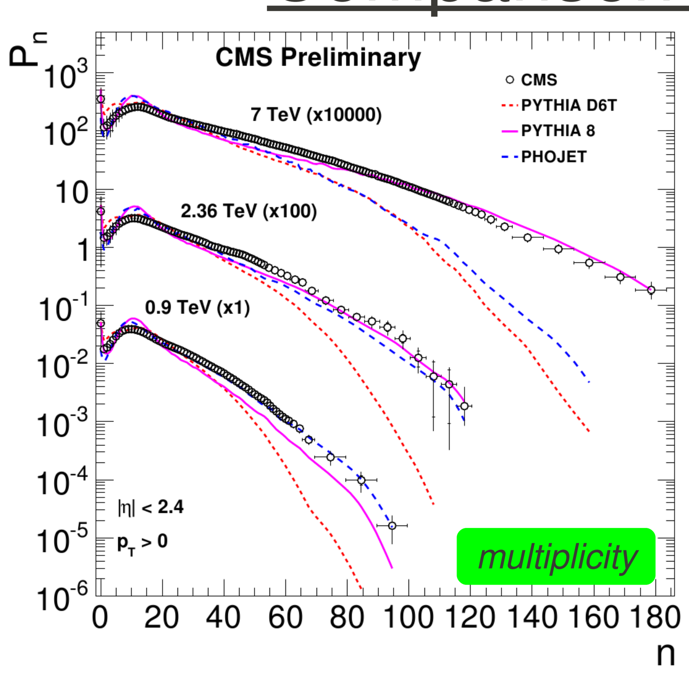


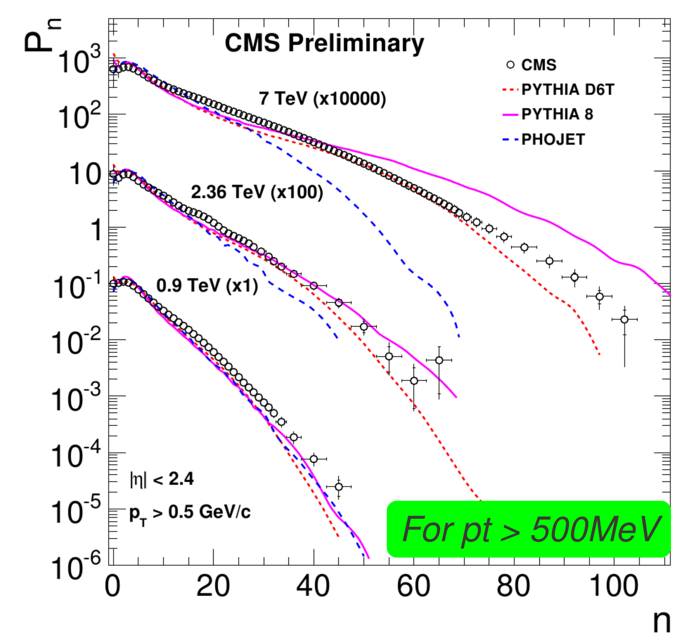




*All compatible with other experiments*

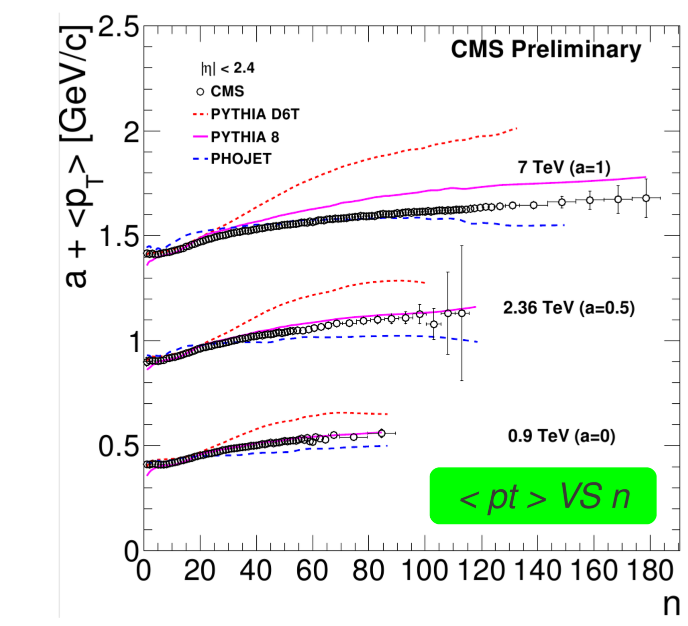
## Comparison with models




*multiplicity*




*For pt > 500MeV*




*< pt > VS n*

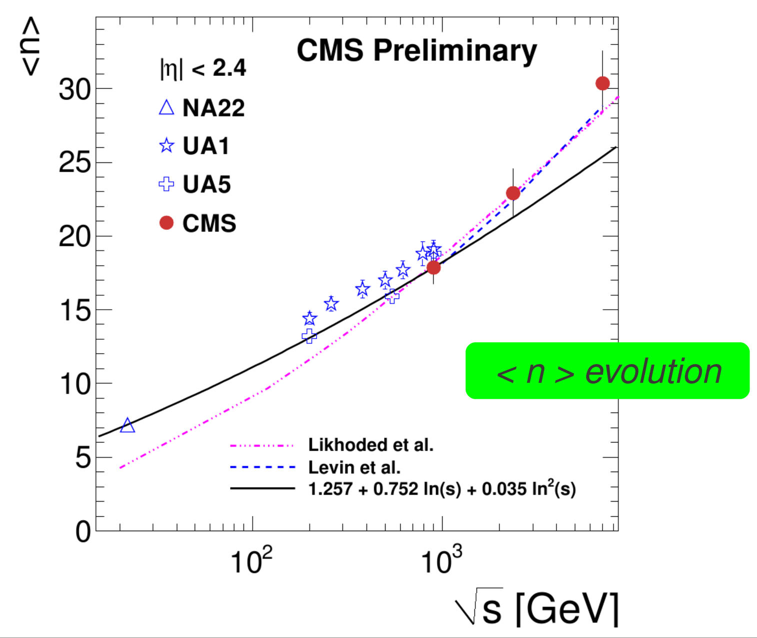
*All 3 Monte-Carlo models (PYTHIA D6T , PYTHIA 8, PHOJET) have a different physical description of the soft particle production mechanism*

**PYTHIA D6T** *produces too few high-multiplicity events but too many high-pt particles, which compensate with pt>500 MeV*

**PYTHIA 8** *describes the multiplicity tail at the 3 energies, but produces too many high-pt particles at 7 TeV, thus overestimates the multiplicity tail with pt>500MeV*

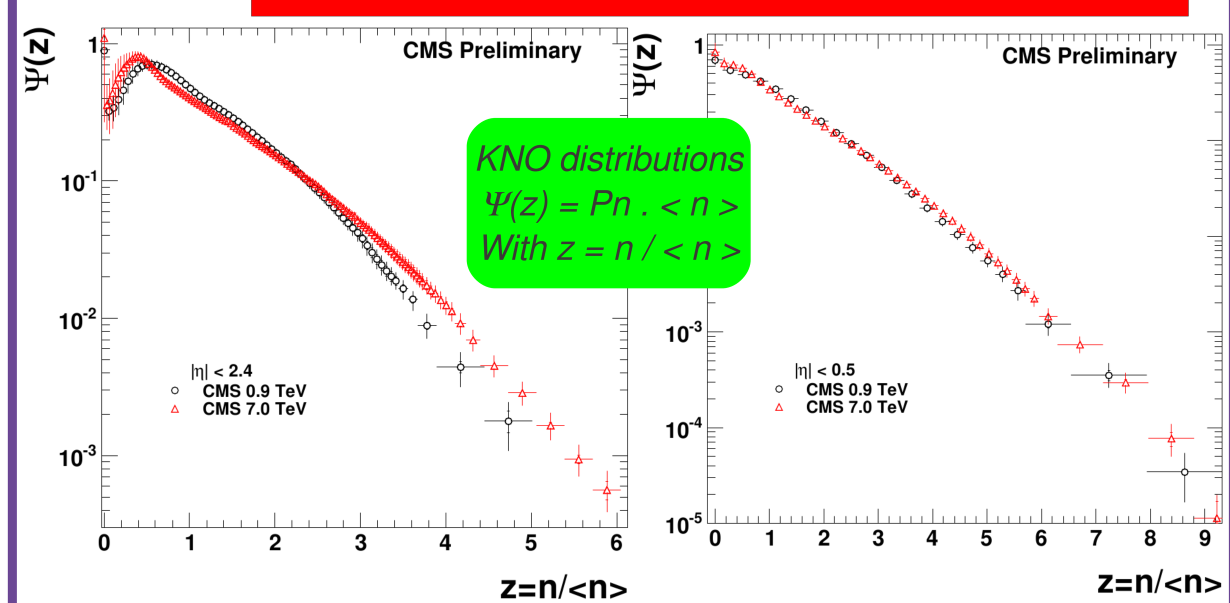
**PHOJET** *produces as well too few high multiplicity events at 7 TeV, and underestimates the <pt> which hardly increase with the multiplicity*

## evolution with energy



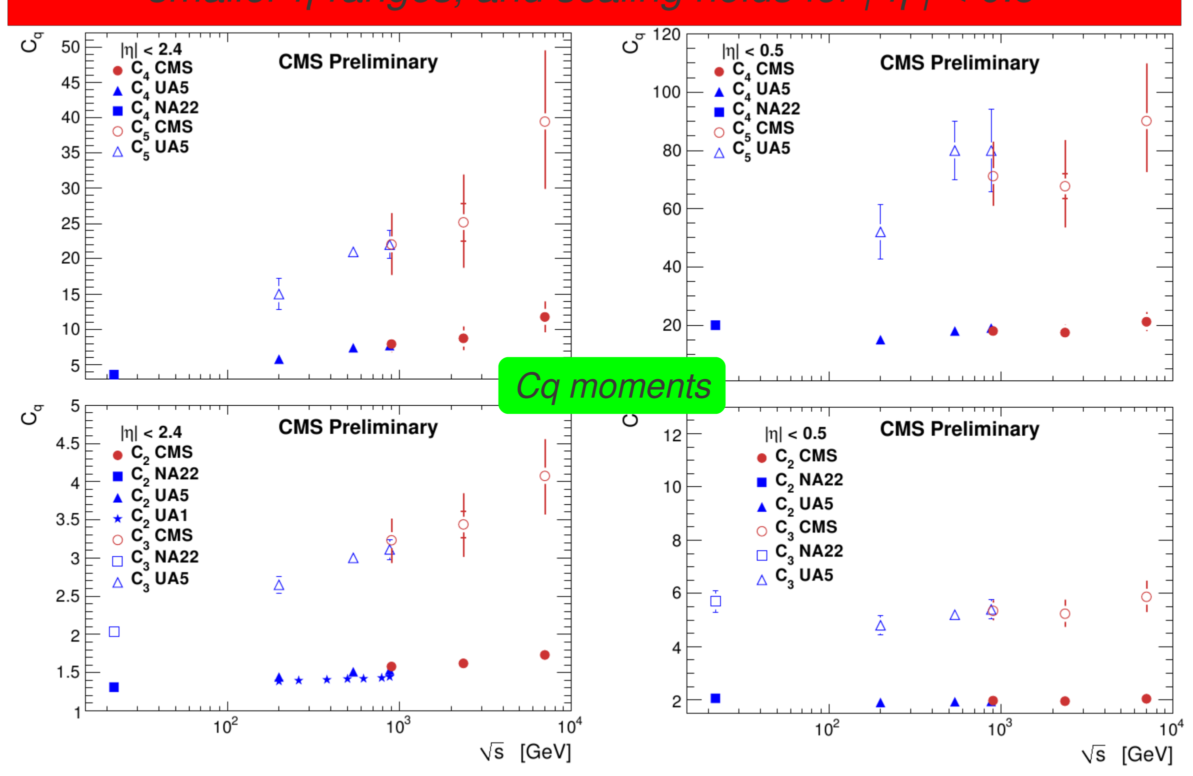

*< n > evolution*

*Increase is higher than expected from simulation, but Regge-inspired ( Likhoded [2] ) or gluon saturation (Levin [3]) models describe well the data*




*KNO distributions*
*Ψ(z) = Pn . < n >*
*With z = n / < n >*

*The multiplicity in KNO form shows a scaling violation between 900 GeV and 7 TeV, which is also visible in the rise of the Cq moments with energy. This scaling violation decreases with smaller η ranges, and scaling holds for | η | < 0.5*




*Cq moments*

[1] : G. D'Agostini, "A Multidimensional unfolding method based on Bayes' theorem", Nucl. Instrum. Meth. A362 (1995) 487–498. doi:10.1016/0168-9002(95)00274-X
[2] : E. Levin and A. H. Rezaeian, "Gluon saturation and inclusive hadron production at LHC", arXiv:1005.0631.
[3] : A. K. Likhoded, A. V. Luchinsky, and A. A. Novoselov, "Light hadron production in semi-inclusive pp-scattering at LHC", arXiv:1005.1827.